INDOOR AIR QUALITY ASSESSMENT

District Court of East Norfolk County
(Quincy District Court)
1 Dennis Ryan Parkway
Quincy, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment

April, 2002

Background/Introduction

In response to a request from The Honorable Mark Coven, Presiding Judge, an indoor air quality assessment was done at the District Court of East Norfolk County [Quincy District Court (QDC)] , 1 Dennis Ryan Parkway, Quincy, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). Concerns about indoor air quality and water damage in offices on the ground floor prompted the request.

On January 3, 2002, Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), made a visit to this building. The QDC is a two-story, redbrick, steel frame building constructed in 1971. The building is constructed so that the ground floor is a full story below street level. The ground drops approximately 10 feet from street level. The drop consists of a grass-covered embankment. The first and second floors house courtrooms, clerks' offices, and probation offices. The ground floor contains offices, cafeteria and the prisoner cell block. Casement type windows are openable in a number of areas in the building. A number of offices do not have openable windows. Interior walls appear to consist of gypsum wallboard covered with vinyl wallpaper.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, model 8551.

Results

The courthouse has an employee population of approximately 140 and is used by over one thousand individuals on a daily basis. Tests were taken under normal operating conditions and results appear in Tables 1-5. Air sampling results are listed in the tables by location that the air sample was taken.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were above 800 parts per million parts of air [ppm] in nineteen out of forty-eight areas sampled, indicating inadequate fresh air supply in some areas. Ventilation is provided by air handling units (AHUs) with fresh air intakes located at the rear of the building (see Picture 1). Fresh air is distributed to areas of the building by fresh air diffusers connected to ductwork. Air is returned to AHUs through wall-mounted grilles connected by ductwork.

Offices in a number of areas are equipped with a fan coil unit (FCU) (see Figure 1). FCUs are located on exterior walls underneath windows. The purpose of the FCU is to provide heating or cooling by circulating air. FCUs do not introduce fresh outdoor air, but rather draw air from the room through a filter in the base of the cabinet into fans. Fans force air through coils that heat or chill the air. Conditioned air exits the FCU through fixed louvers on the top of the cabinet. FCUs were not operating in most offices evaluated.

Some areas in the basement were renovated in a manner to separate the fresh air supply diffuser from the return air vent. Others, such as the bookkeeping area, were reconfigured so that airflow to the hallway was altered. In addition, security windows were installed, enclosing the room. This room also had several computer monitors and central processing units. Each of these electronic devices can produce waste heat, which is expelled into the office space while operating. With the reconfiguration, the ability for air to flow to and from the bookkeeper's office is restricted. This problem exists for most occupied areas in the basement. Two return air vents exist in the basement in hallway walls. With the reconfiguration of floor space and change in the use of the basement, environmental pollutants would be expected to accumulate.

Many offices do not have exhaust ventilation. This system is designed to use hallways to draw return air from office areas. Private office doors have been undercut to have an approximate one-inch space, through which air is to be drawn by the return vents into adjacent rooms. To enhance this effect, operating FCUs create positive air pressure in these offices forcing air through the space. Therefore in this system, air is drawn to each return vent located in nearby rooms. Without FCU operation, the pressurization of each room is minimized, resulting in a possible build up of environmental pollutants in each office.

To maximize air exchange, the BEHA recommends that all components of the ventilation system (e.g., supply ventilation, exhaust ventilation and FCUs) operate continuously during business hours. Without the HVAC system operating as designed, normally occurring pollutants cannot be diluted or removed, allowing them to build up and lead to indoor air quality/comfort complaints. In order to have proper ventilation, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this occurs a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week based on a time weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches.

Temperature readings (68^o to 78^o F) were within the BEHA recommended range for comfort in most areas. The BEHA recommends that indoor air temperatures be maintained in a range between 70^o to 78^o F in order to provide for the comfort of building occupants.

The relative humidity in the building was within a range of 17 to 25 percent, which was below the BEHA recommended comfort range in all areas. Please note that the BEHA recommends a range of 40-60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. It is important to note, however, that relative humidity measured indoors exceeded outdoor measurements (range +1-4 percent). This increase in relative humidity can indicate that the exhaust ventilation is not sufficient to remove normal indoor air pollutants (e.g., water vapor from respiration). Moisture removal is important since the sensation of heat conditions increase as relative humidity increases (the relationship between temperature and relative humidity is called the heat index). As indoor temperature rises, the addition of more relative humidity will make occupants feel hotter than the actual temperature. As an example, a temperature of 75^o F with relative humidity of 50% would produce a heat index so that an individual would feel the temperature as equivalent to 81^o F (USFA/FEMA, 2000). If moisture is removed, the comfort of the individual is increased. Removal of moisture from the air, however, can have some negative effects. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

A number of sources of mold colonization exist in areas within the building. As previously mentioned, fan coil units provide both heating and air-conditioning. Each FCU has drip pans to collect and drain condensation from cooling coils. The manufacturer of the FCUs installed a plastic liner to protect the drip pans from water damage (see Picture 2). Several units were examined and were found coated with dirt and other debris, which can serve as growth mediums for mold when these units are activated for air conditioning. Several employees indicated that mold odor emanates from the FCUs when activated. The drip pan collectors (see Picture 3) are also coated with dirt and debris, suggesting that these units are not routinely cleaned.

Several notable conditions concerning window frame water leakage were also observed (see Picture 4). Efflorescence was noted, which can indicate chronic exposure to rainwater penetrating through window frames or exterior wall cladding. Efflorescence is a characteristic sign of water damage to brick and mortar, but it is not mold growth. As moisture penetrates and works its way through mortar around brick, water-soluble compounds in bricks and mortar dissolve, creating a solution. As the solution moves to the surface of the brick or mortar, the water evaporates, leaving behind white, powdery mineral deposits. Over time, this condition can result in the breakdown of brick and mortar. Water penetration in this manner can create microbial growth problems if it chronically moistens porous materials. In the case of the QDC, efflorescence was noted in offices with vinyl wallpaper around window frames. Vinyl wallpaper is a water impermeable covering that will prevent water evaporation. Wallpaper paste can serve as a mold growth medium if chronically wet, particularly if covered with vinyl wallpaper. Areas with efflorescence were free of mold-related odors and visible mold growth, which would indicate that water affected the edges of vinyl wallpaper sheets, which dried after losing adherence to the water damaged walls. If visible mold growth or related odors manifest in the future, removal of the vinyl wallpaper would be advisable.

The juvenile probation office in the basement has a chronic water penetration problem through the foundation wall. This problem appears to be related to the combination of the design of the exterior wall and the existence of a line of bricks along the brick apron that surrounds the edge of the building. The basement of the building is at a level that is a minimum of 10 feet below street level. This building configuration required that drains be installed along the perimeter of the building to intercept groundwater rolling down the embankment from the street and parking lot to prevent flooding of the basement during rainstorms. This drainage system is installed within a brick apron installed along the edge of the building (see Picture 5). Rainwater striking the exterior of the building would roll down the exterior brick curtain wall and be drained away by the same system. Along the base of the wall is a line of brick (see Picture 6), which may serve as a berm to block groundwater contact with the foundation wall. Over time, rainwater has contacted the junction between the exterior wall and this line of brick, resulting in the breaking of the mortar seal. This space now allows for water runoff from the exterior curtain wall to pass into the space between bricks and pour water against the foundation wall. Plants have colonized this seam (see Picture 7), which widens the space, increasing the breach to allow for more water contact with the foundation wall. Water has worn through seams in the foundation and primarily migrates into the basement in the juvenile probate court. Significant signs of rainwater penetration exist at the foundation floor junction in this office, including silt (see Picture 8), water damaged carpet and ant infestation (see Picture 9). The American Conference of Governmental

Industrial Hygienists (ACGIH) recommends that porous materials such as carpet, cardboard and other porous materials be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Water-damaged porous materials cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy porous materials is not recommended. Fungal microbial growth begins once water soaks porous materials. The fungus grows through its lifecycle, which produces spores. Dependent on the species of fungi, some spores are extremely buoyant and can be drawn into the interior of the room by operation of the ventilation system. In order to prevent further water penetration, measures to eliminate rainwater runoff along the exterior curtain wall above the juvenile probation office need to be implemented.

The QDC has a ceiling tile system that is glued directly to the ceiling in a number of areas (see Picture 10). Several hallways and offices have ceiling tiles that appear to be water-damaged by old roof leaks. Replacement of these ceiling tiles is difficult, since their removal appears to necessitate the destruction of the tile, which can result in the aerosolization of particulates.

Several offices contained a number of plants. Moistened plant soil and drip pans can provide a source of mold growth. Plants are also a source of pollen. Plants should be located away from the air stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the area. Plants should have drip pans to prevent wetting and subsequent mold colonization. Over watering of plants should be avoided and drip pans should be inspected periodically for mold growth.

Other Concerns

An examination of the AHU in the mechanical room found an ajar panel in the ductwork (see Picture 11). Ajar panels can result in mechanical room particulate and odors being entrained into this duct and distributed by the AHU to occupied areas.

Each FCU is also outfitted with a filter. Filters were either undersized or did not fit properly into racks (see Picture 12), which can result in unfiltered return air to be redistributed into the office during FCU operation. This results in dust, dirt and other debris being distributed by the ventilation system. FCUs and AHUs are equipped with filters that strain particulates from airflow. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed. The dust spot efficiency is the ability of a filter to remove particulates of a certain diameter from air passing through the filter. Filters that have been determined by ASHRAE to meet its standard for a dust spot efficiency of a minimum of 40 percent would be sufficient to reduce airborne particulates (Thornburg, D., 2000; MEHRC, 1997; ASHRAE, 1992). Note that increased filtration can reduce airflow produced by the unit by increased resistance (called pressure drop). Prior to any increase of filtration, each FCU should be evaluated by a ventilation engineer to ascertain whether they can maintain function with more efficient filters.

The interiors of several FCUs were examined. As FCU motors operate, the fan chamber depressurizes, drawing air from the room into the cabinet through the return vent. If holes exist in the fan chamber, air may also be drawn from the chambers containing controls and utility pipes. If holes into the exterior wall cavity exist in the controls and utility pipe chambers, then air debris can be drawn into the fans and distributed into rooms. Each FCU examined had holes in the fan chamber walls as well as openings into the exterior wall cavity (see Picture 13) from the controls and utility pipe chambers. In this condition, air and pollutants can be drawn into fans and distributed into offices.

Conclusions/Recommendations

The configuration of drainage outside, around the juvenile probation office, appears to be responsible for causing water damage in this area. In order to address the conditions listed in this assessment, recommendations to improve indoor air quality in this building are divided into **short-term** and **long-term** corrective measures. The **short-term** recommendations can be implemented as soon as possible. **Long-term** solution measures are more complex and will require planning and resources to adequately address the overall indoor air quality concerns. In view of the findings at the time of the visit, the following conclusions and recommendations are made:

Short-Term Recommendations

1. Contact the manufacturer to identify the proper procedure to disinfect FCU drain pans. Examine whether plastic liners can be replaced to prevent microbial growth.
2. Clean the interior of FCUs.
3. Once cleaned and operational, operate FCUs during business hours to enhance exhaust of air from private offices.
4. Remove water damaged materials from the juvenile probation office, including carpeting.
5. With a reduction of relative humidity, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can

be enhanced when relative humidity is low. An increase in filter efficiency in the HVAC system may also be advisable. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

6. In order to decrease aerosolized particulates, disposable filters with an increased dust spot efficiency can be installed in FCUs. Ensure that installed filters are of a proper size and installed in a manner to eliminate particle bypass of the filter. Note that increased filtration can reduce airflow produced by the FCUs by increased resistance. Prior to any increase of filtration, each unit should be evaluated by a ventilation engineer as to whether they can maintain function with more efficient filters.
7. Render airtight all open pipes and spaces around pipes in FCU cabinets.

The following **long-term measures** should be considered:

1. Runoff rainwater from the exterior wall must be prevented from entering the brick junction shown in Figure 2. The most efficient method to prevent rainwater penetration would be to remove all plants from this seam and install a flashing system over the brick to direct rainwater onto the building apron (see Figure 3). Consider consulting a building engineer to examine this or other feasible options to prevent water penetration. Once rainwater penetration is remediated, repair the foundation wall in the juvenile probation office and remove ant infestation.
2. Water-damaged ceiling tiles should be replaced. These ceiling tiles can be a source of microbial growth and should be removed. Source(s) of water leaks (e.g., window

frames and roof) should be identified and repaired. Examine the non-porous surface beneath the removed ceiling tiles and disinfect with an appropriate antimicrobial.

3. Consideration should be given to installing/extending exhaust ventilation to all occupied areas in the basement.
4. Consider replacing vinyl wallpaper around windows with an alternative covering that is water permeable. Repair water damaged plaster once window leaks are remediated.

References

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Figure 1 **Fan Coil Unit (FCU)**

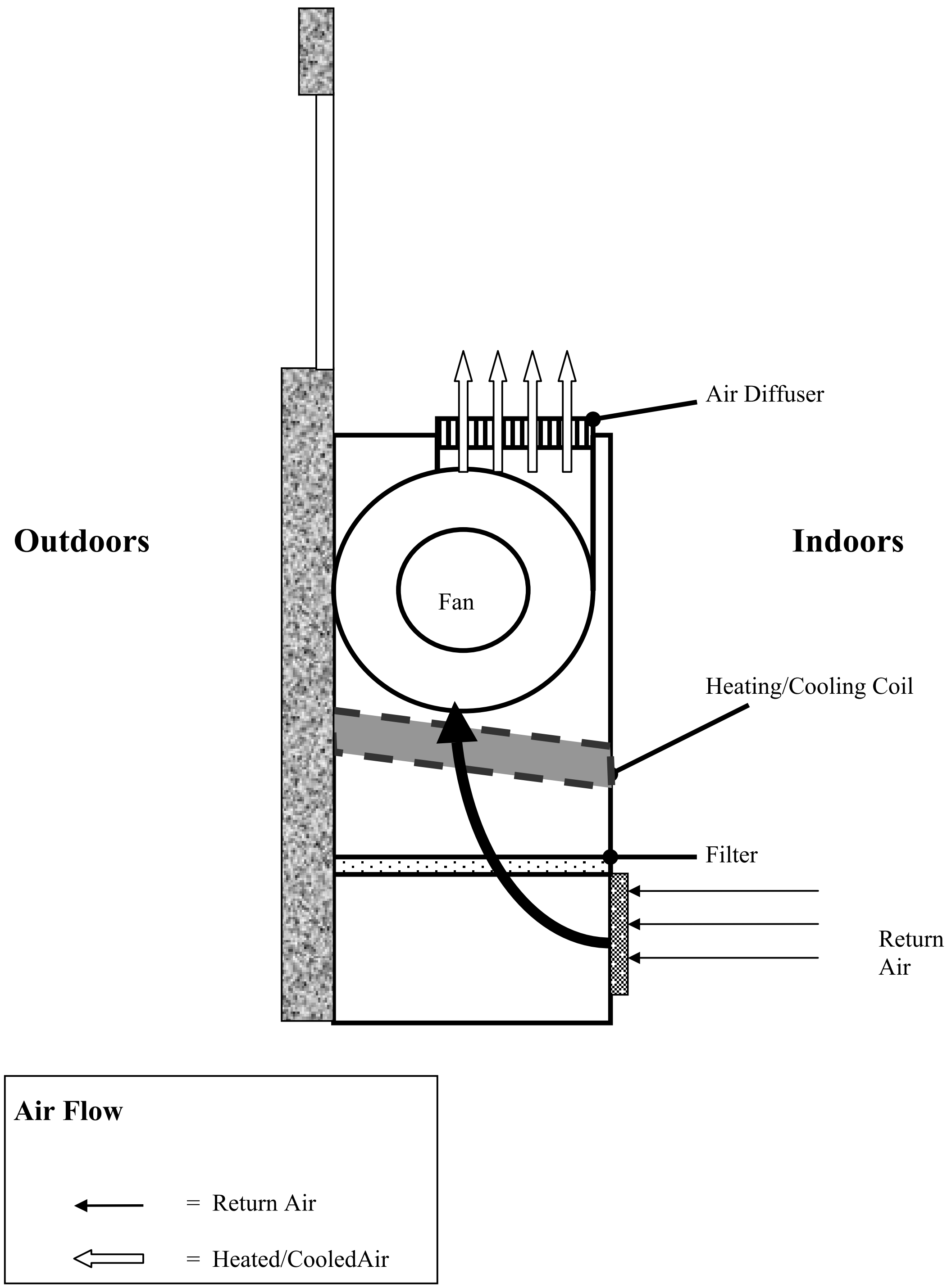


Figure 2
Movement of water into the foundation from drainage plane and exterior wall

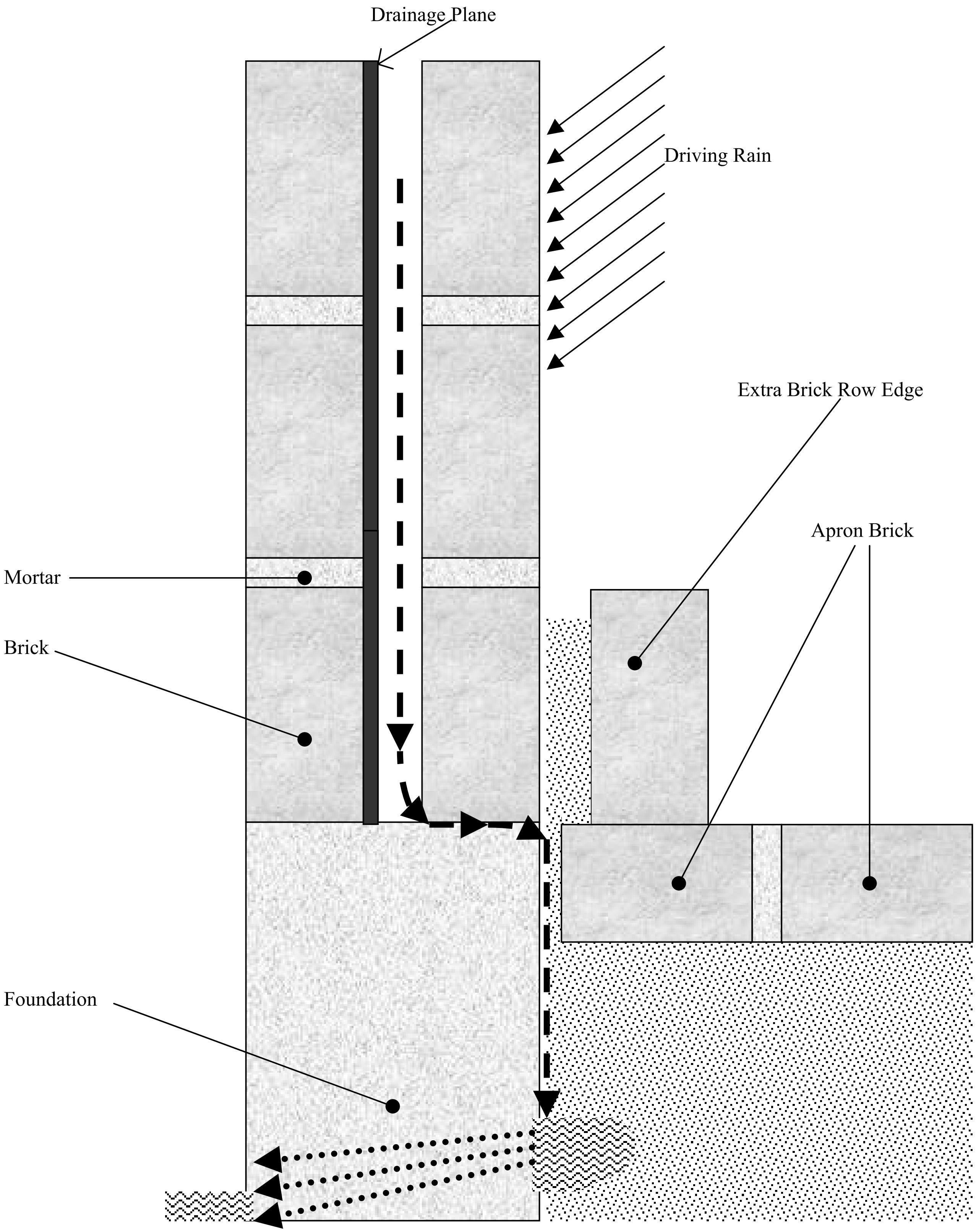
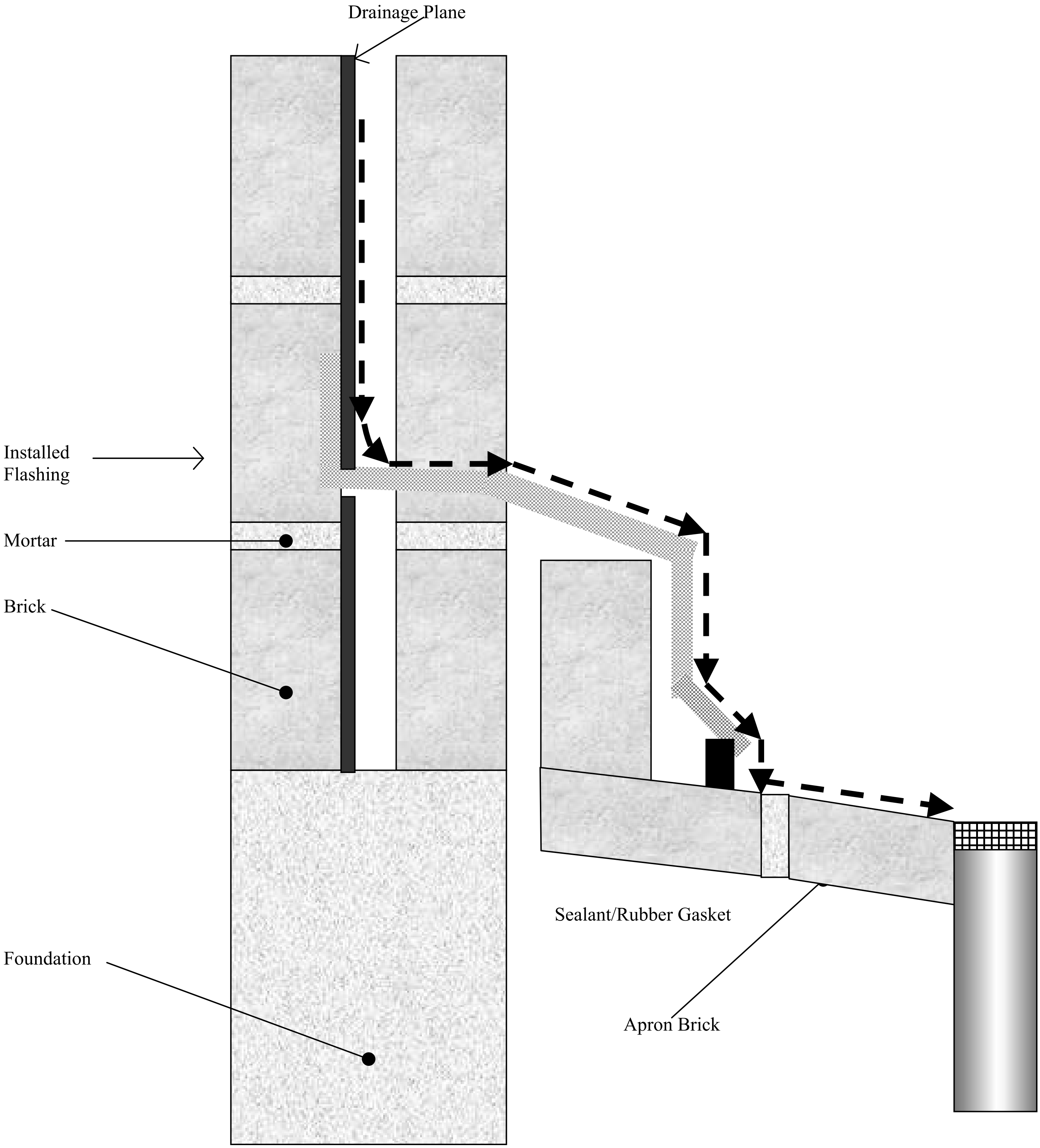


Figure 3
Installation of Flashing to Remove Water from Drainage Cavity



Picture 1

AHU Fresh Air Intakes

Picture 2

Caked Debris on Drain Pan Liner. Note Duct Tape

Picture 3

Drip Pan Collector Coated With Debris

Picture 4

Window Frame Water Leakage, Note Peeled Vinyl Wallpaper

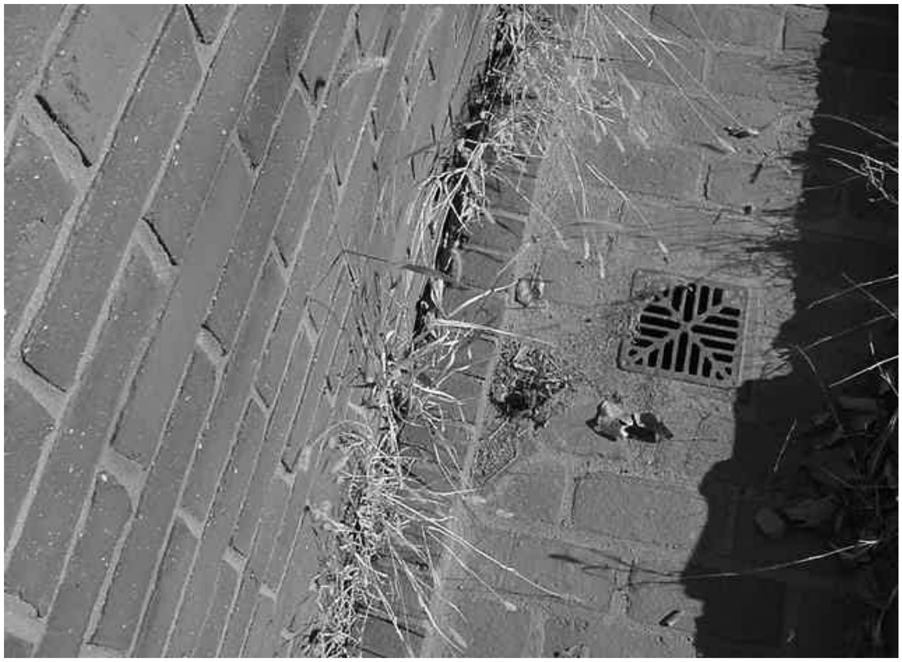
Picture 5

Brick Apron Around the Edge of the Building, Note Seam between Bricks

Picture 6

Line Of Brick Along Base Of Exterior Wall Outside Juvenile Probation Office, Note Lack Of Window Or Overhang That Would Impede Rainwater Runoff

Picture 7

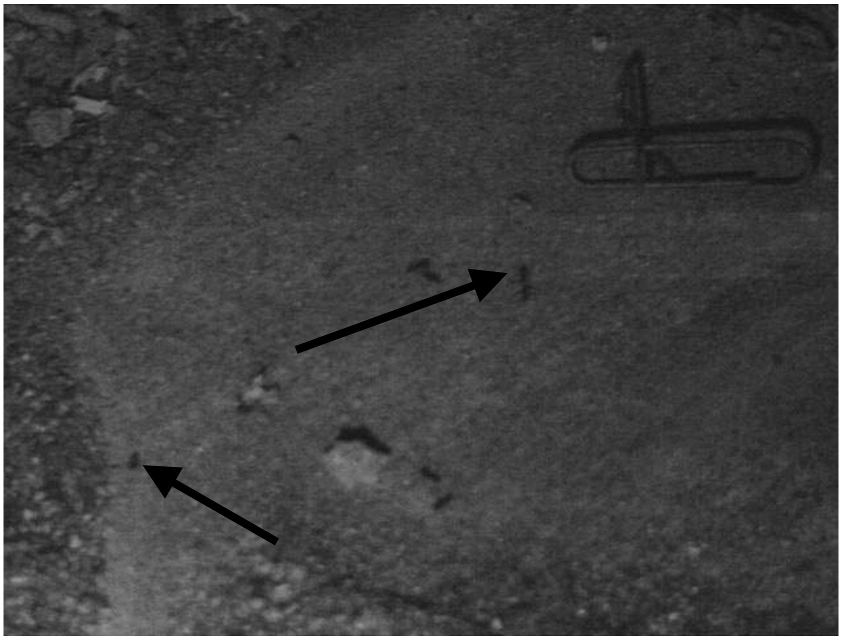


Plants In Seam at Base of Building

Picture 8

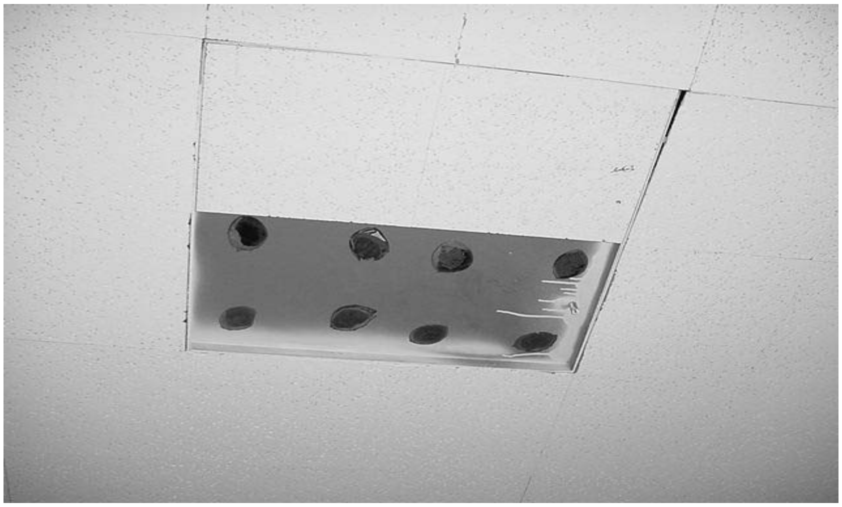
Accumulated Silt in the Juvenile Probation Office

Picture 9



Ants under Carpet in Silt in Juvenile Probation Office

Picture 10



Glued On Ceiling Tile

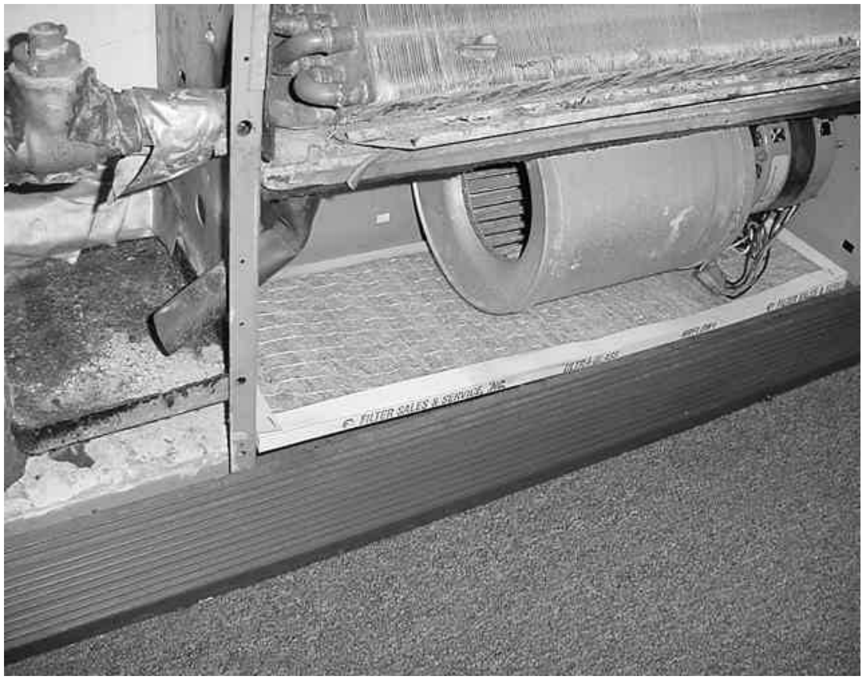
Picture 11

Ajar HVAC Duct Panel In Mechanical Room

Picture 12

Ajar Filter in FCU

Picture 13



Holes In the Fan Chamber Walls As Well As Opening into the Exterior Wall Cavity

TABLE 1

Indoor Air Test Results – District Court of East Norfolk County (Quincy District Court), Quincy, MA – January 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Outside (Background)	377	52	22					
Mines Office	747	73	19	1	No	Yes	Yes	Door open
Lobby	916	73	20	30+	No	Yes	Yes	10 water damaged CT, supply-light fixture, front door
Clerk's Office	858	73	20	22+	Yes	Yes	Yes	8 water damaged CT, plants, door open
Abany Office	880	74	20	1	Yes	No	No	FCU-off, 3 water damaged CT, door open
Clancy Office	954	75	21	1	Yes	No	No	FCU-off, door open
Alexander Office	1001	75	20	1	Yes	No	No	2 FCU-off, 6 water damaged CT, plants, door open, ionizer
Bloom Office	890	74	19	0	Yes	No	No	FUC-off, spray wax
Dalton Office	882	73	20	1	Yes	No	No	FCU-off, 10 water damaged CT, spray wax, door open
Vault Upstairs				1	No	Yes	No	Supply off, wall cracks, door open

*** ppm = parts per million parts of air**
CT = ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – District Court of East Norfolk County (Quincy District Court), Quincy, MA – January 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Vault Lower	948	71	25	0	No	No	No	Door open
Juvenile Probation	991	73	23	6	Yes	Yes	No	Water damaged carpet-ants, 1 ajar CT, 10 water damaged CT, door open
Bookkeeping	747	70	21	2	No	Yes	No	Door open
Bambrick Office	620	71	20	1	No	Yes	No	1 ajar CT, door open
Ridge	623	72	19	1	Yes	Yes	No	Door open
Adult Probation	683	72	20	2	Yes	Yes	No	3 water damaged CT, door open
Restraining Orders	681	73	20	2	Yes	Yes	No	6 water damaged CT, door open
Employee Lounge	787	73	20	3	No	Yes	No	
Small Claims	725	72	20	3	No	Yes	No	Door open
Cordiero Office	561	72	19	0	No	Yes	No	Door open

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TABLE 3

Indoor Air Test Results – District Court of East Norfolk County (Quincy District Court), Quincy, MA – January 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Fox Office	728	72	19	0	No	Yes	No	1 ajar CT, door open
Capala Office	767	72	20	2	No	Yes	No	Door open
Judge's Lobby	1106	71	24	3	No	Yes	No	Supply off, FCU-off,
Judge's Lobby	941	72	22	1	Yes	No	No	FCU, window and door open, water damaged wall-plaster
Court Room Management	820	72	21	0	Yes	Yes	No	Supply off, door open
Lee Office	1157	73	22	1	Yes	Yes	No	FCU-off, supply off, 6 water damaged CT, efflorescence, door open
Guarino Office	965	74	21	2	Yes	Yes	No	Supply off, FCU, paper printer, door open
Mattie	1024	75	22	1	Yes	Yes	No	Supply off, door open
Office	1113	78	21	0	No	Yes	No	Supply off-FCU, 1 water damaged CT, door open
Lounge	778	75	18	0	No	Yes	Yes	Door open

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TABLE 4

Indoor Air Test Results – District Court of East Norfolk County (Quincy District Court), Quincy, MA – January 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Intake	Exhaust	
Adult Probation	816	74	19	15	Yes	Yes	Yes	Plants, door open
Lagree Office	829	74	19	1	Yes	Yes	Yes	Door open
Cellblock Control	721	71	20	1	No	Yes	No	10+ water damaged CT, cells-no door vents
2nd Floor Lobby	585	68	22	15	No	Yes	Yes	1 CT ajar, 10+ water damaged CT
Courtroom B	418	71	18	0	No	Yes	Yes	
Courtroom A	474	70	19	0	No	Yes	Yes	
Jury Pool Room	536	72	19	0	Yes	No	No	Window open, FCU, 35 capacity
Deliberating Room	446	71	17	0	No	Yes	No	
Probation Intake	518	71	18	2	No	Yes	Yes	1 CT ajar, door open
Police Prosecutors	715	71	19	5	No	Yes	Yes	

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Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 5

Indoor Air Test Results – District Court of East Norfolk County (Quincy District Court), Quincy, MA – January 3, 2002

Location	Carbon Dioxide *ppm	Temp. °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation Intake	Ventilation Exhaust	Remarks
Counsel Office	571	72	20	0	No	Yes	Yes	
DA's Outer Office	608	71	19	2	No	Yes	Yes	Door open
DA's Inner Office	572	72	19	1	No	Yes	No	Door open
2nd Session	702	72	20	25	No	Yes	Yes	
2nd Floor Cafeteria	1080				No	No	No	Restroom-exhaust off-light switch activated
3rd Session	450	71	17	0	No	Yes	Yes	Exhaust obstructed by bench
2nd Floor Conference Room	1080	71	21	0	No	No	No	Restroom exhaust vent off
Horrigan	691	71	19	0	No	Yes	Yes	Exhaust obstructed by chair
1st Session	506	72	17	0	No	Yes	Yes	

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